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MEMO

VIA FACSIMILE

To: Fiona Branton
From: Paul Misener
Subject: Response to Apple Presentation
Date: August 18, 1995

With the help of Advisory Committee and Grand Alliance technical experts, I have prepared for you the following informal technical response to the points made by Apple to ITI and to the IEEE-USA meeting. I hope this is helpful. I look forward to talking this afternoon.

I. Introduction

In sum, Apple's objections to the Grand Alliance ATV system under consideration by the Advisory Committee contain technical inaccuracies and/or misunderstandings of the tenets by which the FCC regulates television broadcasting, and a complete lack of consideration of the market economics and operational constraints that face the broadcasting industry. It is fair to say that Apple seeks a computer standard, not an interoperable broadcasting standard.

II. Apple's Basic Assertions

Contrary to Apple's assertion, computer interoperability has not been ignored by the Grand Alliance or in the Advisory Committee process. During the period 1990-1993, when four different digital systems were competing for selection, extensive interoperability reviews were held and a list of recommendations were developed by PS/WP-4. Apple was a key participant in this process. Interoperability criteria were considered and balanced with picture quality, coverage area, and other criteria during the Special Panel meeting in early 1993. Each of the competing systems had different features that provided interoperability advantages, and the Special Panel recommendation to allow improvements or a combination of the proposed systems paved the way for the formation of the Grand Alliance in May 1993. The current Grand Alliance ATV system contains every interoperability feature of all of the predecessor systems and addresses every interoperability consideration developed by PS/WP-4. Further, a digital video workshop co-sponsored by NIST and ARPA, and heavily attended by computer industry companies, endorsed the Grand Alliance system with no dissenting votes. Similarly, a federal Information Infrastructure Task Force committee endorsed rapid adoption of the Grand Alliance system as being critical to the future video rich NII.

Despite the importance of the interoperability of the FCC terrestrial broadcasting standard with computers, it must be kept in perspective. In some instances, interoperability comes at the expense of picture quality, coverage area, or excessive cost to broadcasters or

consumers and, accordingly, must be balanced against these diverse requirements placed upon a terrestrial broadcasting system. Broad uses and application of a terrestrial broadcasting standard are highly desirable, but should not deter the FCC from its primary objective. In fact, the current ATV proposal carefully considers and balances technical parameters that result in a system that serves both entertainment and computing applications, within the constraints that a 6 MHZ broadcast transmission system allows. Of course, the Advisory Committee also has endeavored to facilitate interoperability with other transmission media and devices, including NTSC broadcasting systems.

Apple's seems to believe that televisions and computers should be forced to merge or, more specifically, that televisions should become computer displays. Most experts take a more balanced view that although the convergence of technologies creates opportunities for such merged products, the initiative to create them is best left to competitive forces and consumer acceptance.

Ironically, Apple would need the single TV-computer device standard to come from the television industry because it seems highly unlikely that a single approach could emerge from the computer industry, particularly because that industry has been unable to standardize a uniform display format and frame rate that works across multiple vendors' computers. One need only to look at a mail-order computer catalog to see the incompatibility and lack of interoperability in the computer display market.

Moreover, today's multimedia computers are capable of handling NTSC video, which is fundamentally far less interoperable with computers than the Grand Alliance system. NTSC is the worst of all worlds from a computer interoperability standpoint: it is analog, interlaced, non-square pixels, 59.94 Hz frame rate, etc. And yet, a wide variety of NTSC video related computer products are available from many different vendors, including Apple (*see*, for instance, their center advertising insert in last week's *Business Week*).

If, as Apple warns, a separate ATV system were to emerge for computers, both computer manufacturers and television receiver manufacturers would be free to produce premium products with the functionality to decode both standards. Such products will be technically and economically feasible using software based decoding on high performance microprocessors that will be used in future PCS. In the era of the Internet, decoding software for many different video compression approaches can be downloaded from an online server. In fact, Apple's own Quicktime video software product for the Macintosh allows different types of video compression to be applied to video files. It seems likely that the broadcast ATV standard will be an important format for video, but possibly not the only one -- if only because the computer industry seems to foster diversity.

Finally, in a networked computing environment, the computer industry's own lack of interoperability across vendor-specific operating systems, file formats, and display formats constitutes a *far* more fundamental interoperability barrier than any broadcast ATV issue. Most corporate users of computers continue to be frustrated by the inability of Windows-based PCS, Apple Macintoshes, and various workstations running different flavors of UNIX to share application software and to seamlessly interoperate with text, graphics, sound, and video.

So much for Apple's basic philosophy on ATV. In addition, however, the viewgraphs Apple presented to the ITI contain many specific objections to the ATV system that are flatly untrue, technically inaccurate, or they concern issues that are not relevant to a transmission standard and, thus, are not within the regulatory scope of the FCC or its Advisory Committee.

III. Specific Apple Allegations

A. Interlace Scanning

Apple's objects to the use of interlace in some standard definition ATV formats. Progressive scan, square pixel formats that are VGA compatible (640 x 480) are provided for the SDTV applications of ATV that benefit from their use. Interlace is just another form of compression, which has its place in a multiple format system wherein -- within the constraints allowed by the bit rate that can be transmitted in 6 MHZ -- program producers can choose the format and frame rate that provides the combination of spatial resolution, temporal resolution, and transmission bit rate that is best suited for their application. Each of these parameters has its own associated artifacts, which have different levels of visibility on different kinds of picture content and which must be balanced in a compressed video system.

Indeed, reducing spatial resolution results in fuzzy, unclear pictures that are unacceptable in many applications. Reducing frame rate results in jerky motion. Reducing bit rate results in blockiness and noisy pictures. The use of interlace is a compromise between spatial and temporal resolution that simultaneously provides smooth motion rendition and full vertical resolution on still pictures. This approach has served television quite well for the last 50 years, and cannot be hastily precluded as one of the format options in an ATV system. Apple's attempt to limit the scope of format choices available to content producers is inconsistent with the flexibility in its own Quicktime product and, more fundamentally, it ignores scientific principles and good engineering practices which enable moving images to be represented in the format that represents their content with the least objectionable degradation.

Apple claims that perfect de-interlacing is theoretically impossible. Although it is true that certain pathological cases can be identified where de-interlacing algorithms will not properly remove interlace artifacts, these pathological cases are of little practical consequence.

The kinds of pictures, text, and graphics that are commonly used in both television and computers can be de-interlaced extremely well. The television industry has been developing de-interlacing techniques for well over 10 years and the performance of de-interlacers will be a source of competition among manufacturers. Furthermore, contrary to Apple's assertion, a de-interlacer is not a large expense. Relative to the complexity of High Level MPEG-2 decoders and the other functionality required in an ATV receiver, a very good de-interlacer can be provided in receivers at small incremental cost. The level of IC technology used to produce a cost-effective ATV receiver (or a high performance microprocessor) allows a de-interlacer to occupy a small portion of a single IC. The consensus opinion of the five consumer electronics and/or IC manufacturers in the Grand Alliance (Thomson, Philips, Zenith, GI and AT&T) who are committed to produce ATV receivers with de-interlacing circuitry credibly rebuts Apple's unsubstantiated assertions.

B. 60 Hz Scanning Rate

First and foremost, Apple's arguments relate to display issues that have nothing to do with a transmission standard. The notion that a transmission frame rate is tied to display frame rates is an obsolete technical concept. The ATV system allows transmission at 23.98, 24, 29.97, 30, 59.94 and 60 Hz. These rates are adequate to represent a wide range of camera panning and motion rendition. Of course, motion picture films successfully continue to use a 24 Hz frame rate despite the fact that higher frame rates are technically possible. Double or triple shuttering is used to reduce display flicker in theaters, with 48 Hz being the most common display frame rate for film. In computers, where there is no standard for display format or frame rate, it is the responsibility of software to determine the method of conversion between source and display frame rates. Some software alters the speed of the video clip to match the display frame rate, while other software occasionally repeats (and/or deletes) frames. A similar approach has been successfully used for showing 24 Hz films on 59.94 Hz television for over 40 years. Apple's own Quicktime product is an example of such video display software, which is capable of showing 59.94 Hz video on either 66 Hz or 75 Hz Apple computer screens.

As for Apple's assertion that 70+ Hz is required for displays, it is notable that many computer screens (including most of Apple's) run at 66 Hz. It seems rather strange that while Apple is such a staunch advocate of 72 Hz, it makes 66 Hz and 75 Hz displays for its Macintosh computers, but no 72 Hz display. (If it's such a good idea - why not?) Computer displays are also available at 60 Hz and a wide variety of other rates. The real technical need is to achieve a display rate that is adequate to eliminate human perception of large area flicker. Perceptibility of flicker is a function of display brightness and viewing distance (flicker is actually more perceptible in peripheral vision than in foveal vision). Flicker perceptibility is a rather smooth function of display rate that has no sharp threshold. Thus, it is not surprising that a wide variety of computer display rates have proliferated. Also, the requirements of

entertainment displays are different than computer displays, which are scrutinized at very close viewing distances. Entertainment television display has been sufficient at 60 Hz, and no need for higher display rates is accepted by the consumer electronics industry, particularly since a higher display rate increases cost. Receiver manufacturers are free to provide any display rate or rates that they desire, and accomplish this with either multi-scan displays or electronic frame rate conversion.

The MPEG-2 standard used in ATV identifies its frame rates in a header/descriptor, but despite extensive participation by computer companies, no explicit provision was made for a 72 Hz frame rate in the MPEG-2 header. Many representatives of the computer industry participated in the MPEG-2 process (indeed, as you know, ITI is the secretariat for the U.S. MPEG group), and Apple's assertion that 72 Hz transmission represents computer industry interests is unsubstantiated by the facts.

The observation that 24 Hz movie transmission (provided by the ATV system) would look very good on a 72 Hz display is quite correct. But the display frame rate (or rates) used by ATV receiver or computer manufacturers is outside the domain of a transmission standard and the regulatory authority of the FCC. Further, it is a product decision that is best left to the competitive marketplace. Any HDTV manufacturer can provide 72 Hz display capability as a competitive feature. As for handling 60 Hz transmissions on a 72 Hz display, this requires the very same ratio conversion as the 50 to 60 Hz conversion that is routinely performed when European television is aired in the US.

C. Lack of Data or Code Capability

Apple's assertion that the ATV system has no data or code capability is totally unfounded. The Grand Alliance prototype hardware has been subjected to extensive bit error rate measurements in both Laboratory and Field testing. These measurements document the bit error rate performance of the system as a function of carrier-to-noise ratio (CNR). In any wireless transmission system, the CNR at a given receiving location is a function of transmitter power, RF propagation, and receiver antenna gain.

Of course, viewable picture and acceptable audio tests at error rates in the 10^{-4} to 10^{-6} range are being tested - this is what determine the limits of television service broadcast in the extremely difficult VHF/UHF over-the-air environment. The fact that picture and sound can tolerate higher error rates than pure data is a fundamental characteristic of their nature. Since the ATV channel will be allocated to broadcasters for the primary use of providing television service to the public, it is entirely appropriate to establish planning factors that reflect the requirements for this application. Other frequency allocations for data PCS and wireless LANs (such as proposed by Apple) would undoubtedly consider different requirements for their primary use.

Of course, error free data transmission is not guaranteed by any transmission system (particularly not by telephone modems used extensively for computer communications). In fact, communications theory tells us that there is a fundamental tradeoff between channel capacity and BER - raising the bit rate on a given medium inevitably increases the BER. Except near the limits of ATV coverage, a BER in excess of 10^{-9} is easily achieved and is more than adequate for most data applications. Further, near the limits of ATV coverage, BER improves by about one order of magnitude for a 0.25 dB improvement in CNR, meaning that consumers requiring better error rates for data applications can simply purchase a better antenna to improve their data reception reliability. In computer communications, it is up to the end-to-end application to ensure that usable data has been reliably received. Protocols like FTP apply error detection codes to assure the correct receipt of data - similar software approaches can be applied to data broadcast in the ATV channel by those applications that require it.

D. Non-Square Pixels

Apple's arguments for square pixel formats center on applications that require overlay of geometrically accurate circles. Although this is certainly a virtue of the Grand Alliance HDTV and 640 x 480 SDTV formats, it must be recognized that not every application has such a requirement.[1] Apple's position on this issue is philosophically similar to their position on interlace. Despite the inclusion of the 640 x 480 (compatible with VGA computer displays) square pixel format in ATV, Apple wishes to deny other users of ATV the flexibility to choose formats with rectangular (non-square) pixels. The non-square pixel standard definition formats (704 x 480 in both 4:3 and 16:9 aspect ratios) are included in ATV to provide interoperability with the large archive of content and the installed base of production facilities of broadcasters. The 704 x 480 format corresponds to an international standard, ITU-R BT.601, that has been the basis for most digital television equipment purchases over the last 10 years, resulting in a substantial archive of programming content in this format. Apple's move to deny the existence of the 704 x 480 non-square pixel formats is odd, particularly because video capture boards that utilize this format in its interlaced form are available for virtually every brand of computer.

E. Lack of Overlay Planes

Apple's perspective assumes that all applications are computer-based and require such capabilities. Overlay planes simply are not required for simple television viewing. The definition of such extensions to basic television service need not be (and should not be) defined as part of an FCC transmission standard. If necessary, they could be subsequently defined

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[1] Apple's viewgraphs incorrectly state that a 640 x 480, 16:9 aspect ratio format is included in the Grand Alliance system. It is not

without delaying the introduction of service. Note that there is no unified computer industry standard for cursor control, text and graphics definitions, standardized color lookup tables, 3-D graphics or window controls, &tc. Microsoft and Apple products are completely different on these issues. They even differ on window controls, and the mouse. Until a single computer industry standard emerges for overlay, any voluntary or FCC-based standards are premature.

F. Requirement to Decode All Formats

Apple's position on this issue is irresponsible - it would let the public buy receivers that will unexpectedly and unexplainably (to them) not function when certain formats are transmitted. The advocated solution of layered compression is impractical. Extensive work in layered coding has shown that it is not as efficient as single layer compression. While such approaches are intellectually appealing and suitable for applications where limited bit rate is not a constraint, this is not a practical approach to providing high quality HDTV pictures in a 6 MHZ channel. Apple's approach is "viewgraph engineering" - it remains totally unsubstantiated. Apple has not demonstrated for the Advisory Committee so much as a single video simulation of the approaches they advocate.

G. Lack of Digital Interface Specification

Apple's allegations on his issue are unwarranted and incorrect. Digital interfaces for consumer television equipment have no place in the discussion of transmission standards. They are totally outside the scope and purview of the FCC and its Advisory Committee process. Of course, the consumer electronics industry recognizes the need to develop such standards. The EIA is the appropriate standards body, and work on developing appropriate interface standards is in progress.

H. Poorly Conceived Aspect Ratios

There are many different film formats - if there were one film standard, HDTV would have used it. The 16:9 aspect ratio is a compromise -- developed by the Hollywood community -- that minimizes the cropping required for pan and scan in the most commonly used film formats; it likewise minimizes the loss of resolution when the original aspect ratio is maintained. Broad national and international consensus on 16:9 goes back to the mid 1980s, when the issue was actively discussed, particularly in a SMPTE standards committee chaired by Universal Studios. It has been used in an HDTV production standard since the SMPTE 240M standard and the ITU-R (formerly CCIR) 50 Hz and 60 Hz production standards were established in the late 1980s

The "any aspect ratio" approach advocated by Apple is unnecessarily complex. The concern voiced by Apple over interpolation required to transform non-square pixel formats to

square pixel ones is simple by comparison to the interpolation needed to handle the variety of aspect ratios that they advocate. The simple solution that Apple totally misses is that by simply performing the letterboxing at the broadcast source, any aspect ratio picture can be transmitted within the 16:9 transmission format. With this approach, ATV does not need any rules and the presentation of picture content in different film formats can be decided on a case by case basis by the program provider, using good artistic judgment.

I. Overscan Not Defined

The discussion of overscan is a receiver issue that has no place in a transmission standard. Although overscan is commonly used in computer monitors, it is not defined or required by any standard. Why should TV be different? Apple's idea of a rigidly defined menu bar is outdated. It's own Macintosh software established the precedent of "tear-off" menus that can be separated from the main menu bar. Software should define "menu items" and leave the presentation details (where the menu is placed and how it looks) to the receiver.

J. Limited TV Colors

Film, printers and TV have different color because they are different physical processes. Nothing about the ATV definition can change that.

Apple's assertions about computer color are misleading - most computers have a very limited color gamut (8-bit color is still quite common). There is no standard for color reproduction in computer monitors, and extremely inconsistent color matching among the many monitors that can be used with a given computer. A problem that Apple fails to acknowledge is that computer graphics are usually rendered in linear space rather than gamma corrected space, resulting in color errors on computer monitors.

The constant luminance principle suggested by Apple was well-understood and rejected by the proponents of all four digital HDTV systems and again subsequently dismissed by the Grand Alliance. Constant luminance has never been used in an imaging system (television or computer). The theoretical advantage of this approach is that transmission errors result in slightly less perceptible visual errors. Even in error-prone analog transmission systems, however, this approach has never had enough practical value to be used in a deployed system. In digital systems that exhibit perfect transmission over a wide range of impairments and then sudden catastrophic failure, constant luminance is of no practical value. It would be interesting to know whether Apple plans to support constant luminance representations in its Quicktime software.

K. Must Deploy Now

Apple's criticism of the Advisory Committee testing methodology is totally unwarranted and irrelevant to the ATV standard. Apple claims that software testing was never done. To the contrary, extensive software testing was done by the Grand Alliance and reviewed by the Advisory Committee during system development. As every video engineer knows, such simulations are a valuable step in developing a viable system design. But every experienced video engineer also has experienced techniques that appear to work well in simulation and exhibit unacceptable performance when implemented in real hardware. Accordingly, and by early agreement of the Advisory Committee, simulations are not sufficiently rigorous for establishing a national transmission standard.

Advisory Committee testing is far more rigorous and spans more material than software simulations. For example, software simulations do not usually adequately test rate control dynamics that involve performance over periods of picture material that fill the buffer and require rate control intervention. This was not of particular concern in developing the generic MPEG-2 standard, which left such details to subsequent competition. It would have been irresponsible for the FCC Advisory Committee to accept that adequate picture quality could be produced at a particular bit rate without hardware verification. It should further be noted that in addition to hardware testing, software verification of certain system aspects HAS been done in Advisory Committee laboratory testing (e.g., MPEG syntax compliance and bit stream splicing). It also should be noted that, in its years of participation in the Advisory Committee, Apple has not presented simulation results for the ideas that it advocates.

L. Migration Strategy

Apple's allegations about migration strategy are way off base. The whole multi-format approach of ATV provides different formats so that each application can use the format most suitable for its particular characteristics. Forcing computer values onto entertainment television makes no more sense than attempting to force every computer display to be 60 Hz and use HDTV colorimetry in order to be TV-compatible. Apple just doesn't accept the fact that other companies PREFER to use formats that Apple doesn't like. (Maybe the FCC should outlaw Microsoft DOS file format, too!)

The approach of ensuring that ATV receivers can decode all formats is a responsible approach that protects the public and content creators from obsolescence. Contrary to Apple's assertion, no one advocates that interlaced content should suddenly become unwatchable on ATV. On the contrary, responsible parties involved in ATV standardization observe that if progressive formats indeed demonstrate their claimed advantages to the public, interlaced formats will gradually fade in popularity; the inclusion of multiple formats allows the

marketplace to determine which formats are most widely used and accepted. Apple's approach is both restrictive and presumptuous.

IV. Concluding Remarks

Apple's continuing confusion between transmission standards and receiver related issues is doing a disservice to the broadcast, consumer electronics, and computer industries. Attempts to regulate ATV receiver performance can only be rationalized if the same rules are applied to computers. The result would be a harmful restriction of diversity and a distortion of marketplace preferences.

The Advisory Committee has sought to develop an *inclusive* standard which addresses the needs of terrestrial broadcasting -- for which this ATV transmission standard is primarily intended -- and all other affected industries. Apple, a company not known for its open systems standards, takes the opposite approach. Having failed to achieve consensus standards in its own industry, it seeks to *exclude* the needs of other industries in the standardization of ATV.